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(71) Applicant: LUCENT TECHNOLOGIES INC.
Murray Hill, New Jersey 07974-0636 (US)

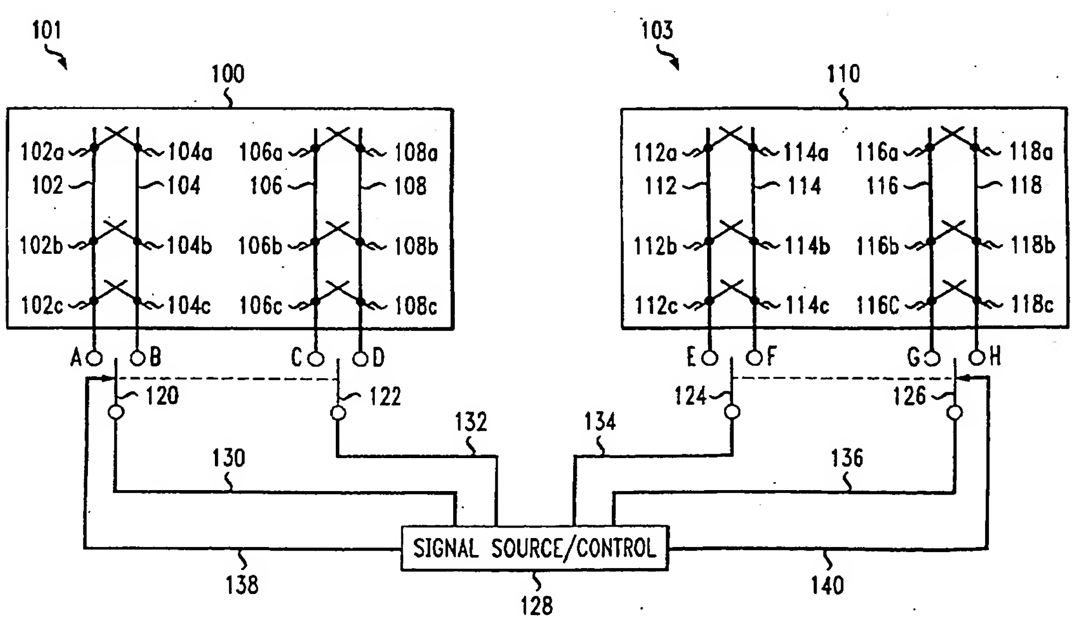
(72) Inventor: Rudrapatna, Ashok N.
Basking Ridge, New Jersey 07920 (US)

(74) Representative:
Buckley, Christopher Simon Thirsk et al
Lucent Technologies NS UK Limited,
Intellectual Property Division,
5 Mornington Road
Woodford Green, Essex IG8 0TU (GB)

(54) Structure for multiple antenna configurations

(57) An antenna array comprises at least two groups (101,103) of antennas where each group comprises at least two pairs of antennas (102, 104; 106, 108). Each of the pairs in a group contains orthogonally polarized antennas (102, 104) and at least one antenna (102) in a pair is similarly polarized to one antenna (106) in at least another pair in the group. The antenna array further comprises circuitry (120 - 128) coupled to the antenna groups to select and activate certain antennas in a group to enable the antenna array to operate in either a beam forming/steering mode, a diversity mode or a MIMO mode or any combination thereof. The antennas in the groups are activated based on the characteristics of the signals being transmitted or received by the antenna array.

FIG. 1



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lation between signals being transmitted (or received) by the antennas decreases. Conversely, as the spacing between antennas decreases, the correlation between signals being transmitted (or received) by the antennas increases. To achieve relatively highly correlated signals in typical wireless communication systems, the spacing between antennas is of the order of $\frac{1}{2}\lambda$ or less where λ is equal to $\frac{c}{f}$ which is the wavelength corresponding to the largest frequency (f) within a band of frequencies at which the antennas are operating; c is the well known constant representing the speed of light in vacuum. It is desirable to have relatively high correlation between signals transmitted (or received) by antennas being used for beam forming/steering applications such as Steered STS. On the other hand, it is desirable to have a relatively low correlation or no correlation between antennas when they are used for MIMO applications such as BLAST or diversity applications.

[0008] Communication systems may use antenna arrays configured to perform beam forming/steering through the use of steered STS. In many situations, these same communication systems have a need to have BLAST capability or diversity capability. In order to perform BLAST operations with their current antenna configurations, such communication systems have to deploy additional antennas appropriately spaced with respect to each other and to the existing antennas. Not only is the deployment of additional antennas a cost increase for service providers, it also presents an environmental and esthetic concern for many communities within which communication towers comprising base station equipment and antennas are located. Service providers are entities that own, operate and control communication networks and their associated equipment. What is therefore needed is an antenna array in which beam forming/steering, MIMO and diversity operations can be performed on signals being transmitted and/or received without having to deploy additional antennas. What is further needed is an antenna array configuration that can perform either MIMO or beam forming/steering or diversity operations, or an antenna array, which simultaneously performs beam forming/steering, MIMO, diversity operations or any combination thereof.

Summary of the Invention

[0009] The present invention is an antenna array comprising at least two antenna groups where each group comprises at least two pairs of antennas where each pair selectively operates in either a MIMO mode, a beam forming/steering mode, a diversity mode or any combination thereof. Each pair of antennas within a group is orthogonally polarized and each antenna in a pair is selectively activatable. One antenna from at least one of the pairs in the group is similarly polarized with one antenna from at least one other pair in the group. A first group of antennas is positioned with respect to a second group of antennas such that there is relatively low correlation or no correlation between signals being transmitted (or received) by any one of the antennas from different groups. The groups are configured such that they operate either in a MIMO mode, a beam forming/steering mode, a diversity or any combination thereof. The groups in the antenna array are coupled to circuitry that cause certain antennas in a group to be selected and activated so that each group is able to operate in any one of the aforementioned modes.

[0010] The antenna groups are coupled to the circuitry via switches which are activated by control signals from the circuitry or are designed to automatically route signals to certain antennas based on certain characteristics of the signals to be transmitted and/or being received. The switches are designed such that they are able to determine certain characteristics from a signal and route that signal to a proper antenna such that the corresponding group to which the switch is coupled can operated in either the MIMO, beam forming/steering or diversity modes. In a preferred embodiment of the present invention, the circuitry is able to determine certain characteristics of signals to be transmitted or being received by the antenna array and, based on the determined characteristics, generate control signals which activate the proper switches that activate certain antennas in a group to cause the group to operate in any one of the three modes or any combination of the three modes. In this manner, different groups can operate in the same mode or in different modes as determined by the circuitry.

Brief Description of the Drawings

[0011]

FIG. 1 depicts a two-group antenna array version of the present invention.

FIG. 2 depicts an alternate configuration for a group of antennas.

Detailed Description

[0012] The present invention is an antenna array comprising at least two antenna groups where each group comprises at least two pairs of antennas where the two pairs selectively operate in either a MIMO mode, a beam forming/steering mode, a diversity mode or any combination thereof. Each pair of antennas within a group is orthogonally polarized with respect to each other and each antenna in a pair is selectively activatable. One antenna from at least one of the pairs in the group is similarly polarized to one antenna from at least one other pair in the group. A first group of antennas is positioned with respect to a second group of antennas such that there is relatively low correlation or no correlation between signals to be transmitted (or being received) by any one of the antennas from different groups. The groups are configured and are positioned

[0018] Signal source/control circuit 128 along with the switches (120, 122, 124 and 126) can be designed to route signals appearing on paths 130, 132, 134 and 136 to be automatically routed to certain antennas based on characteristics of the signals so that any group in the antenna array can operate in either of the three modes. In other words, the switches can be designed to perform self-routing based on the characteristics of the signals appearing on paths 130-136. For example, suppose the antenna array of FIG. 1 is part of equipment used in a Time Division Multiple Access (TDMA) communication network providing voice services (i.e., transmission and reception of voice signals) to some subscribers and data services (i.e., transmission and reception of digital information) to other subscribers. Voice signals are allowed to be transmitted during certain distinct time slots while data signals are allowed to be transmitted during other distinct time slots. Typically, beam forming/steering is a desirable operation to be performed on voice signals while diversity and/or MIMO operations are desirable for data signals. Therefore, the switches (120-126) and signal source/control circuit 128 can be designed to determine the characteristic (e.g., assigned slot) of signals to be transmitted (or received) and route voice signals to one or more antenna groups whose antennas are activated so that such groups beam forming/steering operations and route data signals to antenna groups whose antennas are activated so that they perform diversity or MIMO operations. In similar ways one can design other self routing mechanisms (e.g., code division) to route specific signals to one specific set of antennas (to employ one mode) while simultaneously route another set of signals to another set of antennas (to employ another mode).

[0019] The determination and routing of the signals can be done in either two ways. One way is for signal source/control circuit 128 to determine the type of signal (based on signal characteristics) appearing on paths 130, 132, 134 or 136 and generate control signals on paths 138 and 140 to set the switches to certain positions thus routing the signals to be transmitted and/or received by the antenna array to certain antennas in certain groups allowing the respective antenna groups to operate in either the MIMO, diversity or beam forming/steering modes or any combination thereof. Although not shown in FIGS. 1 and 2, another way is for the switches themselves to route the signals (on paths 130, 132, 134, and 136) based on the characteristics (e.g., frequency content, amplitude, phase, code, time slot) of the signals. Thus, the switches can be designed to be able to process the signals (to be transmitted or being received), determine the characteristics of the signals and route the signals accordingly to allow the antenna array of the present invention to operate in either one of the three modes or operate in any combination of the three modes.

[0020] Other signal characteristics that can be used will depend on the type of communication network for which signal source/control circuit 128 is used. For example, for Code Division Multiple Access (CDMA) networks, each signal associated with a particular subscriber is assigned a distinct code; the code can be ascertained by appropriate processing of the signal to be transmitted and/or being received. Depending on the value of the code, the switches can be designed to route signals having certain code values to certain antenna group or groups which will perform an operation (i.e., MIMO, diversity or beam forming/steering) associated with the code value. Similarly, for Frequency Division Multiple Access (FDMA) networks, which provide access to certain signals based on which frequency spectrum the signals are located, the switches can route the signals to certain antennas in certain groups to allow these groups to operate in any one of the three modes.

[0021] Furthermore, the switches can be designed to route signals to allow certain groups in the antenna array to operate in any of the three modes based on the services associated with the signals. For example, communication networks provide voice services and data services simultaneously to subscribers. Each signal from a subscriber is associated with a particular service. The switches can be designed to determine the service with which a signal is associated and route the signals accordingly to allow certain groups of antennas in the antenna array to process such signals through MIMO, diversity or beam forming/steering operations.

[0022] Still referring to the first group, when switch 120 is set to position A and switch 122 is set to position C, the first group can perform beam forming/steering between signals on paths 130 and 132 since both signals are similarly polarized (both horizontally polarized) by antennas 102 and 106 respectively. Beam forming/steering for the first group can also be achieved by setting switch 120 to position B and switch 122 to position D in which case antenna 108 and 104 are selected and activated by signals on paths 130 and 132. Therefore, selecting similarly polarized antennas from a group of antennas allows the selected antennas to perform the beam forming/steering operation when activated.

[0023] The first group can also be configured to perform MIMO operations such as BLAST or perform diversity operations by selecting and activating orthogonally polarized antennas from the antenna pairs. In particular, when switch 120 is set to position A and switch 122 is set to position D antennas 102 and 108 are selected and are activated by signals on paths 130 and 132 respectively. The signals can be distinct signals that are to be transmitted or are being received using a BLAST code reuse technique or any other MIMO technique. The signals can also be distinct both being received or both being transmitted in a diversity operation. The signals being transmitted and/or received are uncorrelated to each other. Another example is where antenna 102 is receiving a signal while antenna 108 is transmitting another signal or vice versa and both signals fall within the same range of frequencies. Note also that MIMO and diversity

lects and activates at least two similarly polarized antennas in the at least one group to enable the antenna array to operate in the beam forming/steering mode.

5. The antenna array of claim 4 where the beam forming/steering mode is a Steered STS mode.

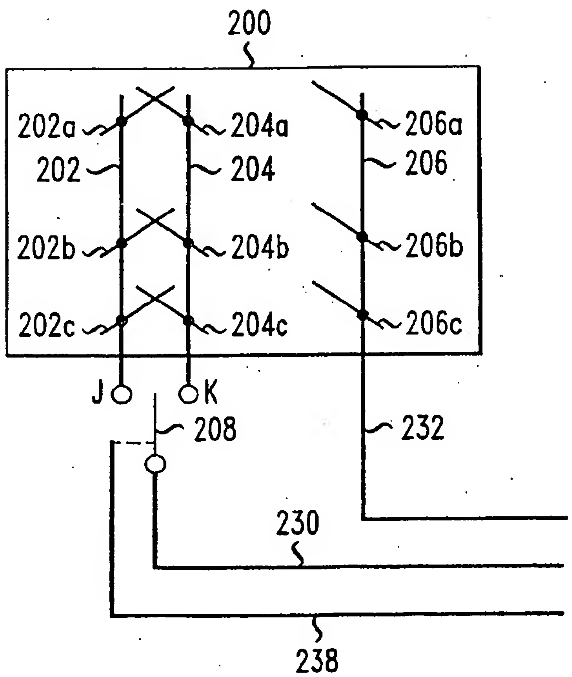
6. The antenna array of claim 1 where the circuitry selects and activates at least two orthogonally polarized antennas in the at least one group to enable the antenna array to operate in the MIMO mode.

7. The antenna array of claim 6 where the MIMO mode is a BLAST mode.

8. The antenna array of claim 1 where the circuitry selects and activates at least two orthogonally polarized antennas in the at least one group to enable the antenna array t operate in the diversity mode.

9. The antenna array of claim 1 where the antennas in the at least one group operate at one frequency or in a same range of frequencies.

FIG. 2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EUROPEAN SEARCH REPORT

Application Number
EP 01 31 0913

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	PASSMANN C ET AL: "A polarization flexible phased array antenna for a mobile communication SDMA field trial" MICROWAVE SYMPOSIUM DIGEST, 1997., IEEE MTT-S INTERNATIONAL DENVER, CO, USA 8-13 JUNE 1997, NEW YORK, NY, USA,IEEE, US, 8 June 1997 (1997-06-08), pages 595-598, XP010228402 ISBN: 0-7803-3814-6 * the whole document * ---	1-9	
A	GB 2 191 044 A (GEN ELECTRIC CO PLC) 2 December 1987 (1987-12-02) * abstract * * page 1, line 93 - page 2, line 49; figure * ---	1-9	
A	GOLDEN G D ET AL: "Detection algorithm and initial laboratory results using V-BLAST space-time communication architecture" ELECTRONICS LETTERS, IEE STEVENAGE, GB, vol. 35, no. 1, 7 January 1999 (1999-01-07), pages 14-16, XP006011643 ISSN: 0013-5194 * the whole document * -----	7	TECHNICAL FIELDS SEARCHED (Int.Cl.7)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	12 April 2002	Angrabeit, F

CATEGORY OF CITED DOCUMENTS

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